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"Moving Advancements into Practice"

MAP Brief April 2018

Best practices and promising technologies that can be used now to enhance concrete paving

Concrete Overlay Performance on Iowa's Roadways

April 2018

ROAD MAP TRACK 6

PROJECT TITLE
Concrete Overlay Performance on Iowa's Roadways

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The Long-Term Plan for Concrete Pavement Research and Technology (CP Road Map) is a national research plan developed and jointly implemented by the concrete pavement stakeholder community. Publications and other support services are provided by the Operations Support Group and funded by the Federal Highway Administration.

Moving Advancements into Practice (MAP) Briefs describe innovative research and promising technologies that can be used now to enhance concrete paving practices. The April 2018 MAP Brief provides information relevant to Track 6 of the CP Road Map: Concrete Pavement Construction, Reconstruction, and Overlays.

This MAP Brief is available at www.cproadmap.org/publications/MAPbriefApril2018.pdf.

Introduction

Pavement preservation and rehabilitation have been growing in importance nationwide. Concrete overlays are a cost-effective, low-maintenance preservation and rehabilitation technique used to extend pavement life. Bonded concrete overlays are used primarily for preservation while unbonded concrete overlays are used primarily for rehabilitation.

Although there are six types of concrete overlays, those constructed on composite pavements are very similar to those constructed on asphalt pavements; therefore, four main types of concrete overlays are often considered. The four types are as follows (see figure 1):

- Bonded Concrete Overlays on Asphalt (BCOA)
- Bonded Concrete Overlays on Concrete (BCOC)
- Unbonded Concrete Overlays on Asphalt (UBCOA)
- Unbonded Concrete Overlays on Concrete (UBCOC)

Background

In Iowa, concrete overlays have been very successful; however, until recently there was not a clear understanding of their overall performance. To remedy this, the Iowa Highway Research Board (IHRB) funded TR-698, Concrete Overlay Performance on Iowa's Roadways. This study is a large-scale, comprehensive and quantitative evaluation of concrete overlay performance. Concrete overlay performance was measured by analyzing the Pavement Condition Index (PCI) and the International Roughness Index (IRI). The PCI is a rating scale from 0 to 100 with 100 (see figure 2).

The IRI has three performance categories based on FHWA (see table 1).

Table 1. International Roughness Index

Ride Quality Terms	IRI Rating (in/mi)
Good	<95
Acceptable	95 to 170
Not acceptable	>170
Source: FHWA and FTA 2006	

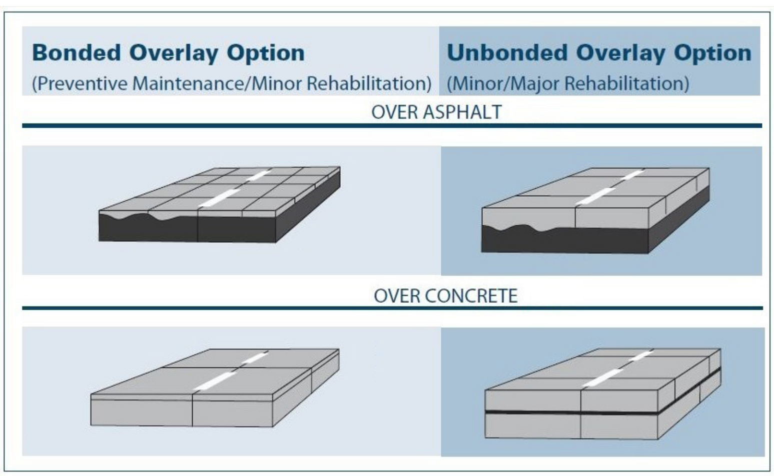

Figure 1. Concrete overlay segments (adapted from Guide to Concrete Overlays, Third Edition, Harrington and Fick 2014)

Figure 2. PCI rating scale

Data Collection

The Iowa Department of Transportation (DOT) has collected pavement condition data such as the IRI, transverse cracking, longitudinal cracking, D-cracking, spalled joints, and faulting on all paved secondary roads since 2002. Since 2013, data collection has occurred on every paved public roadway in Iowa. The Institute for Transportation (InTrans) at Iowa State University manages the pavement condition database as part of the Iowa Pavement Management Program (IPMP). In addition, the Iowa Concrete Paving Association (ICPA) and the Iowa DOT provide a database of historical information on concrete overlay projects, including but not limited to thickness, joint spacing, type of overlay, and traffic.

The two databases were merged to develop a comprehensive performance database on all concrete overlays in Iowa. At the time of the study, approximately 500 concrete overlay projects were in existence within the state of Iowa, encompassing approximately 1,500 miles. After careful review, it was decided to filter the data to remove overlays that were 1) part of research, 2) no longer in service, 3) had miscoded PCI values, and 4) were constructed within the first two of years of the data collection process. After the filtering process, 384 projects remained for the study. Figure 3 shows the locations of concrete overlays included in the study.

Performance Results

Based on analysis of the performance data, the results show the following conclusions, which support the overall good performance of concrete overlays in Iowa based on PCI of good to excellent and IRI of average to good.

- 89% of all concrete overlays had a PCI of 60+ (good to excellent condition)
- 93% of all concrete overlays had an IRI of 170 in/mi and below (average to good condition)

Figures 4 and 5 show data for PCI and IRI performance.

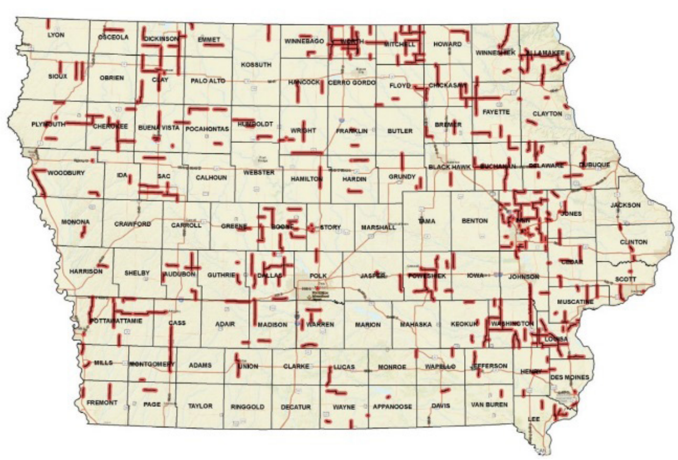

Figure 3. Map of concrete overlays in Iowa

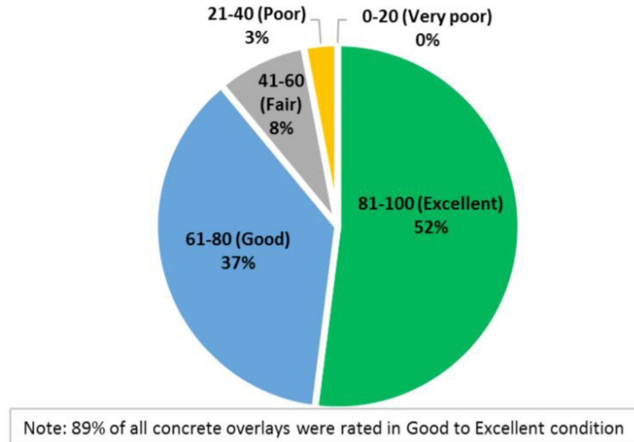

Figure 4. PCI performance, ages 0-37 years

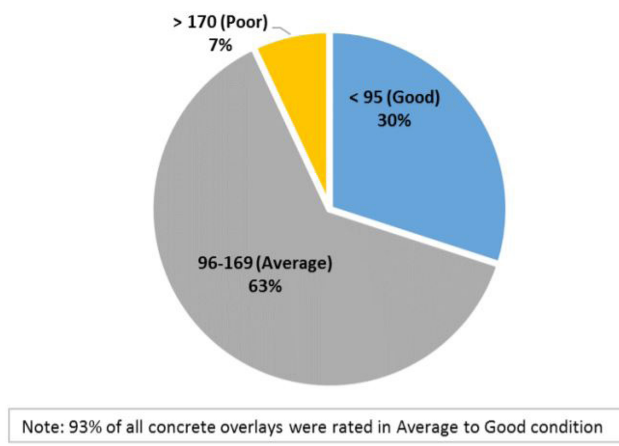

Figure 5. IRI performance, ages 0-37 years

Figures 6 -9 show the PCI performance with age. More than half of the overlays were in good condition (PCI > 60) after 30 years of service life, with 65% of pavements showing PCI performance of over 61. Figures 10 to 13 show the IRI performance with age. After 30 years of service life, 76% of the overlays had average IRI values (< 170 in/mi). This indicates that most of the pavements possessed an acceptable ride quality. It can be concluded from these figures that the overlays in Iowa perform relatively well past their anticipated service life.

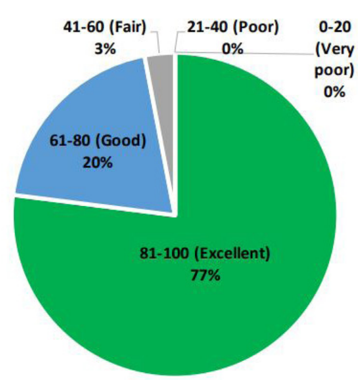

Figure 6. PCI ages 0-10 years

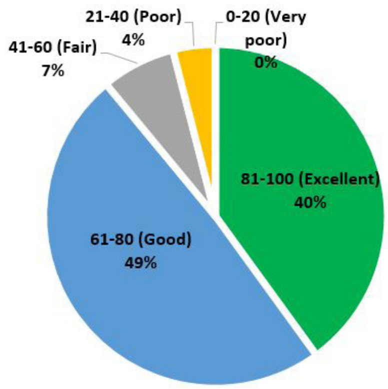

Figure 7. PCI ages 11-20 years

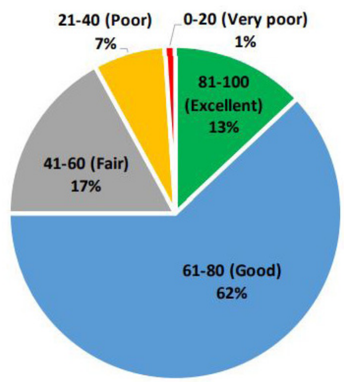

Figure 8. PCI ages 21-30 years

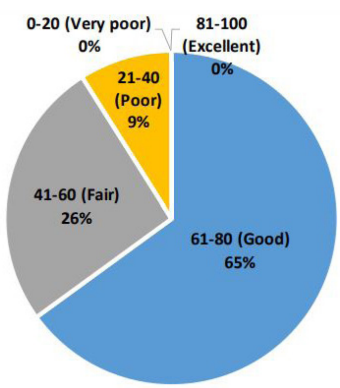

Figure 9. PCI ages greater than 30 years

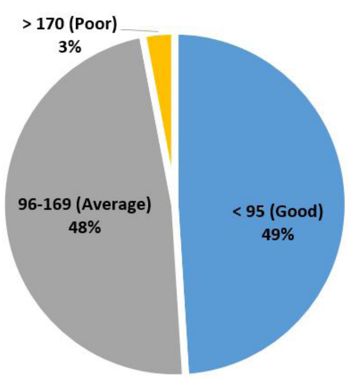

Figure 10. IRI ages 0-10 years

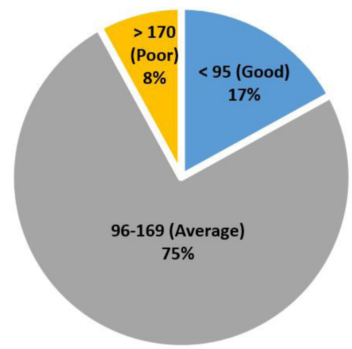

Figure 11. IRI ages 11-20 years

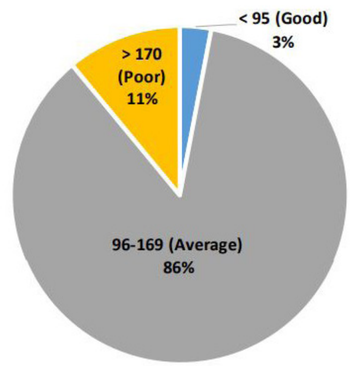

Figure 12. IRI ages 21-30 years

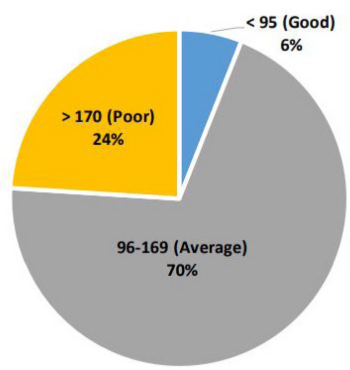

Figure 13. IRI ages greater than 30 years

The results of a scatter plot of the entire concrete overlay dataset (384 projects) show that the majority of projects were on track to achieve good performance (PCI = 60) or better and to maintain ride quality of average (IRI =170 in/mi) or better during the first 35 years of service life, as shown by the Figures 14 and 15 on the following page.

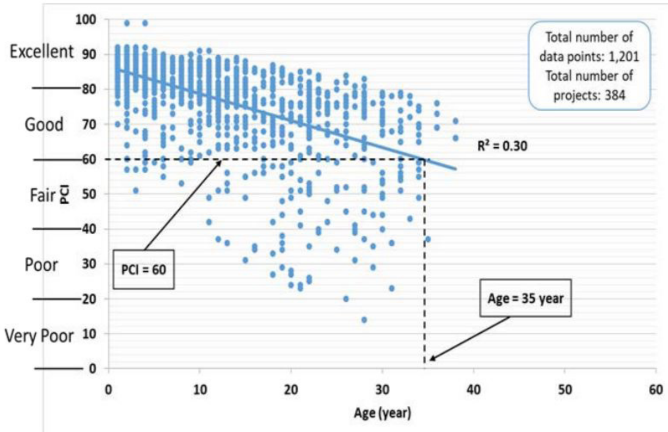

Figure 14. Performance of concrete overlays based on the total database PCI and age

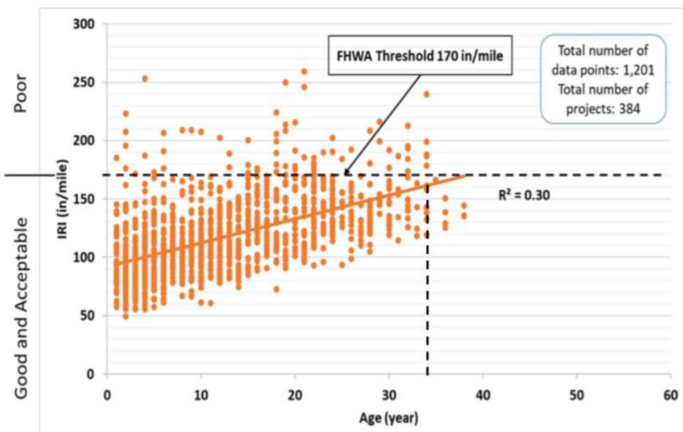

Figure 15. Performance of concrete overlays based on the total database IRI and age

Figure 16-19 show the distribution of the 384 overlay projects by thickness, transverse joint spacing, and traffic, respectively. The majority of overlays (48%) are 6 inches thick, while 2% are less than 3 inches thick. The most common joint spacing is 15-20 ft.

Regarding traffic, 87% of all projects had 2,000 vehicles per day or fewer. A majority (94%) of Iowa's overlays were constructed on secondary roads, while only 4% and 2% of overlays were primary roads and municipal roads, respectively, as shown by Figure 19.

Figure 20 shows PCI versus age for a sample of concrete overlays with 12-ft joint spacing that were less than 20 years old. Well-performing overlays are represented by orange points, and the trend line for that group (orange line) shows approximate 45 years of life at a PCI of 60. Blue data points refer to pavements with deterioration faster than normal. The blue line indicated the linear trend line for the complete data set, showing a pavement age of 27 years at a PCI of 60. Therefore, service life can be greatly improved by taking steps to ensure that good quality pavement is originally placed (effectively removing the blue data points).

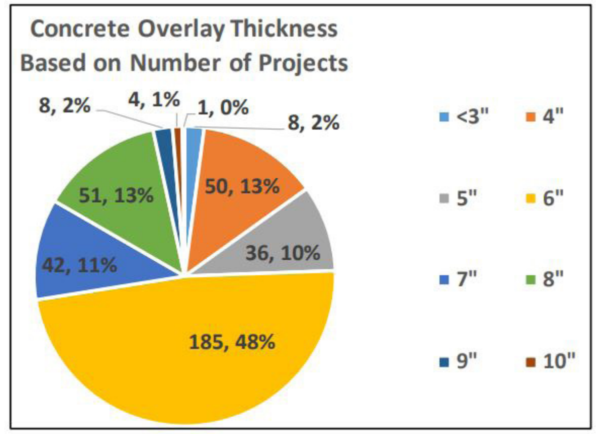

Figure 16. Concrete overlay thickness based on number of projects

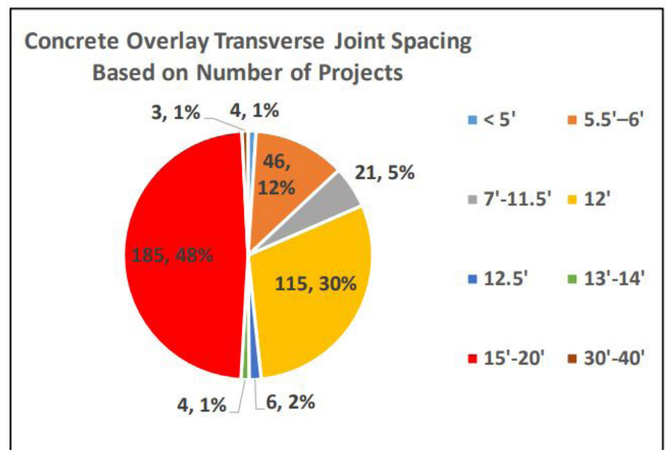

Figure 17. Concrete overlay transverse joint spacing based on number of projects

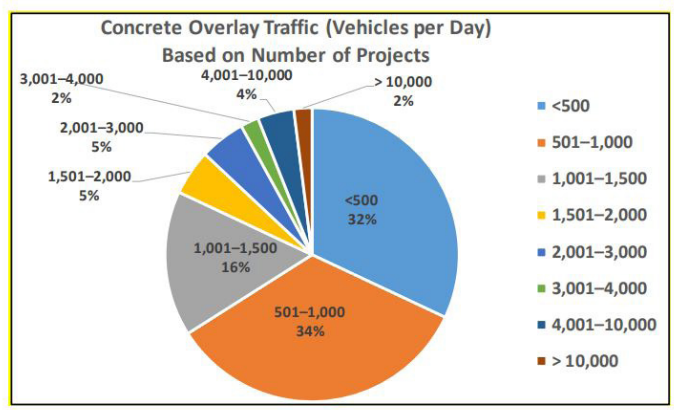

Figure 18. Concrete overlay traffic based on number of projects

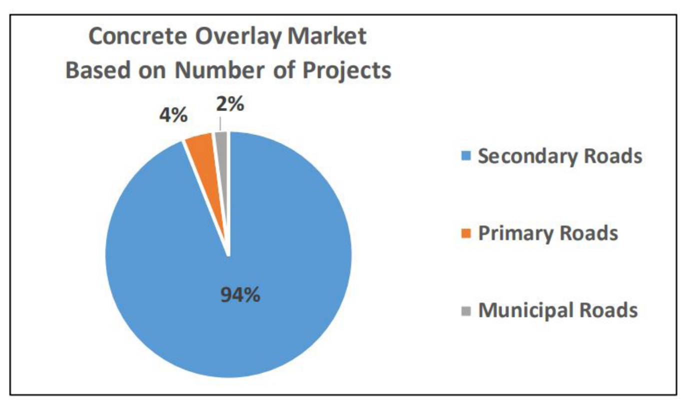

Figure 19. Distribution of Iowa's concrete overlay projects

Optimum Joint Spacing Research

Research is currently being conducted by the Iowa Highway Research Board to help determine the optimum joint spacing for thin (4-6 in.) concrete overlays. The database that was created for the concrete overlay performance research described in this brief is being utilized for this additional research.

Many concrete overlays in Iowa were originally built with longer panel sizes, typically in the 15-20ft range, with no mid-panel longitudinal joints. These overlays have performed well, particularly on lower traffic volume roadways. The majority of the overlays are 6 in. thick. Longer joint spacing is more desirable because it reduces the number of joints, in turn reducing the cost of joint installation and maintenance. However, longer joint spacing can also result in mid-panel cracking, increased maintenance requirements, or rougher pavements due to curling and warping.

For thinner overlays (4-6 in.), the current design approach of determining the spacing of longitudinal and transverse joints results in smaller panel sizes normally in the range of 5.5 by 5.5 ft or 6 by 6 ft. However, some field observations have documented that, for pavements with shorter joint spacing, some joints may not be working effectively (lack of crack deployment under the saw cut, see figure 22), particularly on lower volume roadways.

Figure 22: Lack of crack deployment at a sawed contraction joint

In conclusion, a sawed construction joint where a crack does not deploy increases cost of the project and subjects the pavement to potential distress over the years. In such situations, determination of minimum joint spacing is desired, so determination of the optimal joint spacing for concrete overlays is warranted. This is particularly true for relatively thin BCOA pavements. By optimizing joint spacing, the economy of pavement construction and maintenance may be improved.

Analytical investigation and field testing are being performed to determine the optimum joint spacing for thin concrete overlays based on the following testing parameters: concrete overlay type, thickness, joint spacing and the use of synthetic macrofibers.

With the assistance of Dr. Jeff Roesler, University of Illinois, ultrasonic pulse echo imaging is being utilized to analyze crack deployment on existing concrete overlays and concrete overlay test sections throughout Iowa (figure 23) The research is planned to be complete in 2019.

Figure 23. Ultrasonic pulse echo imaging of concrete overlays to analyze crack deployment

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